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ORIGINAL ARTICLE

Laparoscopic resection of splenic flexure colon cancers: a retrospective multi-center study with 117 cases

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Abstract
The objective is to investigate the short- and long-term outcomes of laparoscopic resections of splenic flexure colon cancers in three Italian high-volume centers. The laparoscopic resection of splenic flexure colon cancers is a challenging procedure and has not been completely standardized, mainly due to the technical difficulty, the arduous identification of major blood vessels, and the problems associated with anastomosis construction. In this retrospective cohort observational study, a consecutive series of patients treated in three Italian high-volume centers with elective laparoscopic resection of the splenic flexure for cancer is analyzed. The observational period was from January 2008 to August 2017. Patient demographics and clinical features, operative data, and short- and long-term outcomes were prospectively recorded in a specific database and were retrospectively analyzed. During the observation period, 117 patients were selected. Conversion to open surgery was necessary in 15 patients (12.8%). Of 102 complete laparoscopic procedures, multi-visceral resection was performed in 13 cases (12.7%). Postoperative surgical complications occurred in 13 patients (12.7%), with 3 cases of anastomotic leak (2.9%) and 3 cases of re-operation (2.9%). The postoperative mortality in this population was null. The 5-year overall survival rate was 84.3%, and the 5-year disease-free survival rate was 87.8%. Laparoscopic resection of the splenic flexure is feasible and safe in high-volume centers. Compared to the results of other laparoscopic colonic resections, the short- and long-term outcomes are similar, but the conversion rate is higher.

Keywords Laparoscopic resection · Splenic flexure · Colon cancer

Background

Colorectal cancer (CRC) is the third most frequent cancer worldwide and the fourth cause of neoplastic death after lung, liver, and stomach cancers. Between 1990 and 2013, the diagnosis of colorectal cancer doubled (from 818,000 in 1990 to 1.6 million in 2013) [1]. Most of this increase can be explained by the growth and aging of the population.

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In Europe, CRC is the second most common malignancy in women and the third most common in men, with a cumulative cancer-related mortality of 12% for both sexes [2]. In Italy in 2016, 52,400 new cases of CRC were recorded and led to death in 18,756 of these patients. In Italy, as in Europe as a whole, CRC is the second most common malignancy in women and the third most common in men, accounting for 12% of new cancers [3].

In more than 85% of cases, CRC is located in the descending colon, ascending colon and rectum [4]. Localization in the colonic splenic flexure is very uncommon and accounts for just 2–5% of all colonic tumors [5]. Colonic splenic flexure cancer (CSFC) is defined as a tumor located within the distal third of the transverse colon and the proximal third of the descending colon [6].

Due to the rarity of this condition, the surgical treatment of SFC remains controversial and has been much debated in recent years. This surgical procedure is not well standardized due to doubts regarding the extent of the resection: the

technical difficulty of the procedure, especially in laparoscopy; the challenging identification of major blood vessels; and the difficulty associated with anastomosis construction.

The aim of this study was to investigate the short- and long-term outcomes of laparoscopic splenic flexure resections for cancer in three Italian high-volume centers.

Methods

Patient selection

Three Italian centers were involved in this study: S. Eugenio Hospital of Rome (the promoting center), Abano Terme Hospital of Padova, and S. Andrea Hospital of Vercelli. All patients who underwent surgery for SFC in these centers between January 2008 and August 2017 were screened for inclusion in the study. SFC was defined as cancer arising in the colonic segment between the distal third of the transverse colon and the proximal third of the descending colon [6].

Adult patients with a splenic flexure cancer who underwent elective laparoscopic resection of the colon were eligible for inclusion. Exclusion criteria were as follows: emergency procedures, ASA IV patients, peritoneal carcinosis, benign disease, synchronous tumors, subtotal colectomies, and laparoscopic exploration of the abdomen that was immediately converted to open surgery without any laparoscopic step in the procedure.

Data collection

For each patient, demographic and clinical features, intra- and postoperative data, pathological findings, and follow-up data were recorded. Demographic and clinical features included the following: age, sex, body mass index (BMI), American Society of Anesthesiologists (ASA) score, previous abdominal surgery (under general anesthesia, laparoscopic, or laparotomic), and symptomatic tumors.

Intra-operative data included the following: operative time, number of trocars, anastomotic technique, conversion to open surgery, and multi-visceral resections.

Postoperative data included the following: time to first flatus, time to first stool, time to complete oral feeding, length of hospital stay, 30-day morbidity, 30-day mortality, and re-operation rate. Postoperative morbidity was defined and classified according to the Clavien–Dindo classification. Severe postoperative morbidity was defined as any complication grade III or IV [7].

Pathologic examination included the following: histotype, disease stage, number of harvested lymph nodes, positive lymph nodes, and specimen length. A tumor was considered mucinous when at least 50% of the tumor showed this histological finding. The tumors were graded according to the differentiation grade into well-, moderately, and poorly differentiated adenocarcinomas on the basis of the poorest differentiated part of the tumor. The tumor stage was determined according to the tumor-node-metastasis (TNM) classification (American Joint Committee on Cancer, 7th Edition) [8].

Length of follow-up was calculated from the discharge date to the date of last clinical evaluation. Follow-up ended on 31 October 2017.

Pre-operative assessment and surgical technique

In all cases, diagnosis and staging were determined based on colonoscopy, tattooing of the cancer site with biopsy and CT scanning. In patients with subocclusion or rectal bleeding, only CT scanning was performed.

All patients received peri-operative antimicrobial and antithrombotic prophylaxis. A urinary catheter was placed at the beginning of each procedure. All patients were mobilized early with removal of the urinary catheter within 48 h. The nasogastric tube was always removed at the end of the operation in all laparoscopic cases that were not converted.

All patients were operated on through laparoscopy according to oncological principles by three surgeons who were highly skilled in both open and laparoscopic colorectal surgery.

The surgical technique used was the same in all three centers. The patient was placed in a supine position with the inferior legs abducted. The left arm was abducted, and the right arm was placed along the body. The surgeon and the first assistant were situated on the patient's right side, and the second assistant was situated between the patient's legs. The laparoscopic rack was located above the left shoulder of the patient.

The procedures started with 3 or 4 trocars, depending on the complexity of the surgical anatomy and the disease. A peritoneal inspection was performed to evaluate the laparoscopic feasibility of the procedure through a 12-mm umbilical trocar. A second 12-mm trocar was subsequently placed in the left flank for use by the operator's right hand, and a 5-mm trocar was inserted in the right hypochondrium for use by the operator's left hand. In the majority of cases, an additional 5-mm trocar, for use by the second assistant's hand, was placed on the left side of the abdomen. In three very difficult cases, one additional 5-mm trocars were placed under the xyphoid process. The trocars were placed in the same positions in all the participating centers, as illustrated in Fig. 1.

On the basis of the site and dimensions of the lesions, three different procedures were performed:

1. Splenic flexure resection, defined as the resection of the colon from the distal third of the transverse colon to the

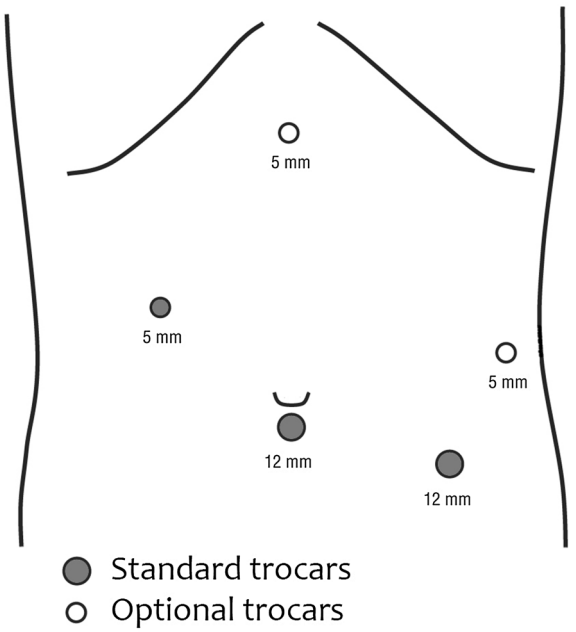

Fig. 1 Trocar positions

proximal third of the descending colon with ligation of the left branch of the middle colic artery and the left colic artery at its origin. The anastomosis was a colo-colic anastomosis.

2. Extended left hemicolectomy, defined as the resection of the colon from the distal third of the transverse to the colorectal junction with ligation of the left branch of the middle colic artery and the inferior mesenteric artery at its origin. The anastomosis was a colorectal anastomosis.
3. Extended right hemicolectomy, defined as the resection from the last small-bowel loop to the proximal third of the descending colon with ligation of the ileo-colic vessels, middle colic vessels and left colic artery. The anastomosis was an ileo-colic anastomosis.

Eighty-six patients (73.5%) underwent segmentary resection of the splenic flexure, 27 patients (23.1%) underwent an extended left hemicolectomy, and 4 patients (3.4%) underwent an extended right hemicolectomy (Table 1). The choice between these three procedures was made by the first surgeon based on his experience.

Table 1 Surgical procedures ($n = 117$)

Splenic flexure resection (n, %)	86 (73.5)
Extended left hemicolectomy (n, %)	27 (23.1)
Extended right hemicolectomy (n, %)	4 (3.4)

Outcomes

The primary outcomes were postoperative 30-day morbidity and mortality, overall survival and disease-free survival.

Overall survival was defined as the time from the first primary cancer diagnosis to death. Disease-free survival (DFS) was calculated from the date of operation to the first observation of disease progression.

Statistical analysis

Quantitative data are reported as the mean ± standard deviation (range). Qualitative data are reported as the number (percentage) of patients.

The Kaplan–Meier method was performed to calculate overall survival (OS) and disease-free survival (DSF).

All analyses were performed using IBM SPSS version 23 (IBM Co., Armonk, NY, USA).

Results

Study population

Retrospective data from a prospective multi-center database of colorectal resections, including 3532 patients, were analyzed. In total, 173 patients underwent colorectal resection of the splenic flexure for cancer, of which 56 patients were excluded. A population of 117 patients was selected for inclusion in the statistical analysis.

A population of 117 patients was selected; 102 procedures (87.2%) were completed using laparoscopy, and 15 procedures (12.8%) were converted to open surgery. The demographic and clinical features of the population who underwent a complete laparoscopic procedure are summarized in Table 2.

Table 2 Demographic and clinical features ($n = 102$)

Sex (n, %)	
Male	45 (44.1)
Female	57 (55.9)
Age, years (mean ± SD, range)	70.2 ± 11.2 (22–90)
BMI, kg/m^2 (mean ± SD, range)	25.7 ± 4.4 (16.0–40.3)
Previous abdominal surgery (n, %)	30 (29.4)
ASA classification (n, %)	
ASA I	14 (13.7)
ASA II	58 (56.9)
ASA III	30 (29.4)
Symptomatic tumors (n, %)	21 (20.6)
Subocclusion	14 (13.7)
Rectal bleeding	7 (6.9)

On 102 complete laparoscopic procedures, 45 males and 57 females were enrolled. The mean age was 70.2 years, the mean BMI was 25.7 kg/m^2, and the rate of the previous abdominal surgery was 29.4%. According to the ASA score, 14 patients were ASA I, 58 patients were ASA II, and 30 patients were ASA III. Twenty-one patients underwent elective surgery for symptomatic tumors (subocclusion and rectal bleeding).

The number of converted procedures appeared randomly distributed over the years without any relationship to the surgical skills or experience (Fig. 2).

Operative Data

As already stated, a population of 117 patients was selected; 102 procedures (87.2%) were completed using laparoscopy, and 15 procedures (12.8%) were converted to open surgery. Nine procedures were converted due to technical difficulties, 5 for extended tumors, and 1 for a major bleeding event not manageable using laparoscopy.

The 102 complete laparoscopic procedures required a mean operative time of 179.4 min (range 90–390 min). The number of trocars used was 3 in 22.5% of procedures, 4 in 74.5% of procedures, and more than 4 in 3% of procedures. A simultaneous resection of other structures was performed in 13 patients (12.7%) who were suspected of having macroscopic tumor infiltration. At least 1 drain was placed in all patients except 3 (2.9%). A diverting stoma was performed in 4 patients, 3 of whom underwent an ileostomy, and 1 of whom underwent a colostomy. Sixty-six patients (64.7%) received an intracorporeal anastomosis, and 36 patients (35.3%) received an extracorporeal anastomosis.

All the intra-operative data are summarized in Table 3.

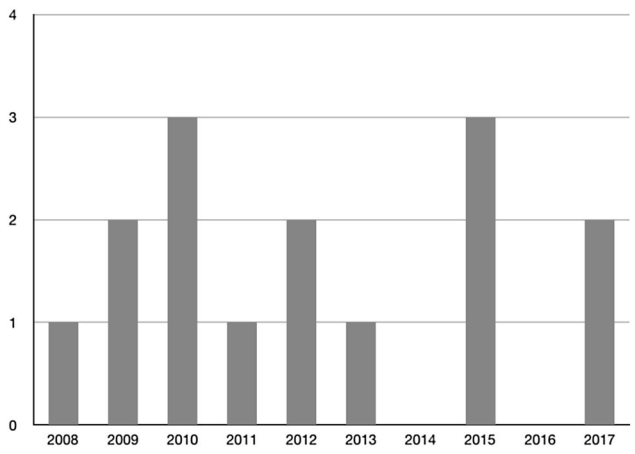

Fig. 2 Converted procedures according to year

Table 3 Intra-operative data ($n = 102$)

Operative time, min (mean ± SD, range)	179.4 ± 68.6 (90–390)
Trocars (*n*, %)	
3	23 (22.5)
4	76 (74.5)
5	2 (2.0)
6	1 (1.0)
Resections of other structures (*n*, %)	13 (12.7)
Peritoneum	10 (9.8)
Stomach	1 (1.0)
Small bowel	2 (2.0)
Drainage placement (*n*, %)	
0	3 (2.9)
1	95 (93.1)
More than 1	4 (3.9)
Diverting stomas (*n*, %)	4 (3.9)
Ileostomy	3 (2.9)
Colostomy	1 (1.0)
Anastomoses (*n*, %)	
Intracorporeal	66 (64.7)
Extracorporeal	36 (35.3)
Conversions on 117 cases (*n*, %)	15 (12.8)
Technical difficulties	9 (7.7)
Extended tumors (T4, bulky)	5 (4.3)
Bleeding	1 (0.9)

Short-term outcomes

The mean time to first flatus was 2.3 days, the mean time to first stool was 3.8 days, the mean time to complete oralization was 3.0 days, the mean time to autonomous mobilization was 2.5 days, and the mean time to removal of the last drain was 5.3 days. It must be considered that this population included 13 patients with severe surgical complications, of whom 7 had a drain for more than 10 days.

Five (4.9%) patients received at least 1 postoperative blood transfusion, and 4 (3.9%) patients had a severe medical complication. Ten patients (9.8%) had a severe postoperative surgical complication, with an anastomotic leak rate of 2.9% (3 patients). These patients underwent a secondary procedure involving exploratory laparotomy with an ileostomy construction.

The mean discharge time was 7.9 days (range 3–35 days). In patients without severe surgical complications, the mean discharge time was 6.4 days.

Five patients were readmitted within 30 days after the operation: 1 for subocclusion, 2 for mild kidney failure, 1 for mild hepatic failure, and 1 for adverse reaction following the beginning of chemotherapy. All received medical treatment alone.

The early outcomes are summarized in Table 4.

Table 4 Early outcomes ($n = 102$)

Time to first flatus, days (mean ± SD, range)	2.3 ± 1.4 (0–9)
Time to first stool, days (mean ± SD, range)	3.8 ± 2.0 (0–12)
Time to complete oralization, days (mean ± SD, range)	3.0 ± 1.6 (1–9)
Time to autonomous mobilization, days (mean ± SD, range)	2.5 ± 1.3 (1–8)
Time to removal of the last drain, days (mean ± SD, range)	5.3 ± 4.3 (2–34)
Postoperative blood transfusions (n, %)	5 (4.9)
Postoperative severe medical morbidity (n, %)	4 (3.9)
Postoperative severe surgical morbidity (n, %)	10 (9.8)
Anastomotic leak	3 (2.9)
Mechanical occlusion	2 (2.0)
Major wound infections	1 (1.0)
Bleeding	1 (1.0)
Intrabdominal collection	2 (2.0)
Reoperations (*n*, %)	3 (2.9)
Ileostomy	3 (2.9)
Postoperative mortality (*n*, %)	0 (–)
Patient able to be discharged, days (mean ± SD, range)	6.6 ± 4.7 (2–34)
Day of discharge, days (mean ± SD, range)	7.9 ± 4.1 (3–35)
Readmission within 30 days (*n*, %)	5 (4.9)

Pathology findings

Eighty-two tumors (80.4%) were adenocarcinomas, and 13 (12.7%) were mucinous adenocarcinomas. Six dysplastic adenomas (5.9%) and one case of colonic localization of B-cell lymphoma were also observed. Eleven tumors were of grade T4 (10.8%). N+ specimens occurred in 39 cases (38.2%), and M+ specimens occurred in six cases (5.9%). All metastatic patients underwent elective resection for sub-occlusion or rectal bleeding.

In this population, 7 patients (6.9%) were diagnosed as stage 0 (including 6 patients with dysplastic adenomas and 1 patient with in situ adenocarcinoma), 23 patients (22.5%) were considered stage I, 33 patients (32.4%) were considered stage II, 32 patients (31.4%) were considered stage III, and 6 patients (5.9%) were considered stage IV metastatic patients.

The mean specimen length was 28.1 cm (range 11–110 cm). The mean number of harvested lymph nodes was 18.3 (range 3–52).

All pathology data are shown in Table 5.

Table 5 Pathology data ($n = 102$)

Tumor histotype (*n*, %)	
Adenocarcinoma	82 (80.4)
Mucinous adenocarcinoma	13 (12.7)
Dysplastic adenoma	6 (5.9)
Other	1 (1.0)
T4 lesions (*n*, %)	11 (10.8)
N+ specimen (*n*, %)	39 (38.2)
M+ patients (*n*, %)	6 (5.9)
Staging (*n*, %)	
0	7 (6.9)
I	23 (22.5)
II	33 (32.4)
III	32 (31.4)
IV	6 (5.9)
Other	1 (1.0)
Specimen length (mean ± SD, range)	28.1 ± 16.6 (11–100)
Harvested lymph nodes (mean ± SD, range)	18.3 ± 8.4 (3–52)

Long-term oncological outcomes

The Kaplan–Meier method was adopted to calculate overall survival (OS) and disease-free survival (DSF), as shown in Fig. 3. The mean follow-up period was 50.4 ± 30.1 months. The 5-year OS was 84.3%, and the 5-year DFS was 87.8%, as detailed in Fig. 3.

Seventeen neoplastic recurrences were recorded: 15 distant metastases and 2 local relapses. The metastatic patients were managed by chemotherapy alone, and the two patients with local recurrences underwent neo-adjuvant chemotherapy and surgical open resection.

Discussion

Until now, there has been no consensus about the surgical management of SFC. The debate is focused especially on the extension of colon resection and on the surgical approach to be adopted (laparoscopic vs open).

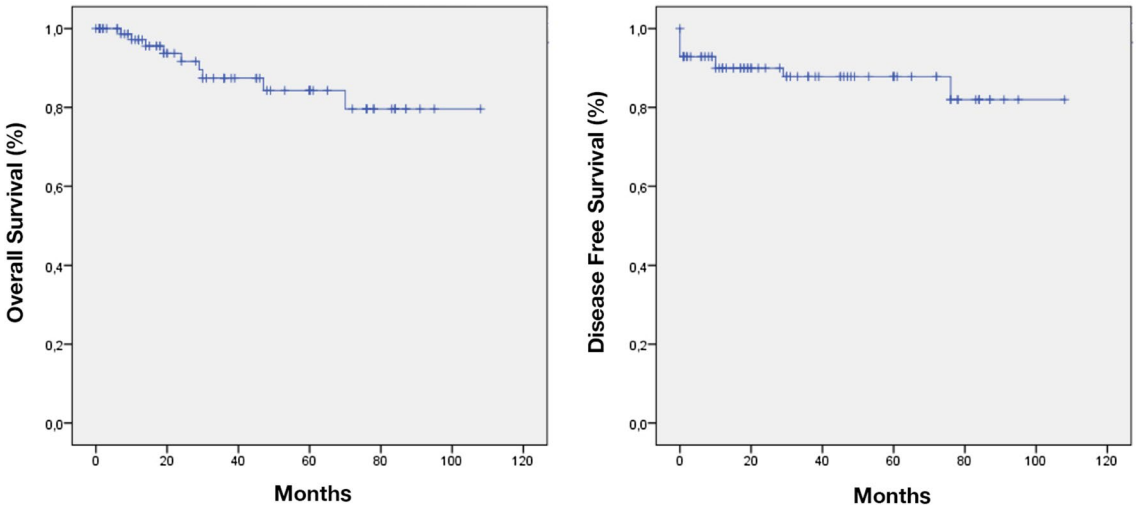

Fig. 3 **a** 5-year overall survival (OS) rate of the patients enrolled in this study was 84.3%. **b** Disease-free survival (DFS) rate of the patients enrolled in this study was 87.8%

Very different extensions of the resection have been described for SFC, varying from a left super-extended colectomy, with or without splenectomy and distal pancreatectomy, to a right enlarged colectomy, as described by Sadler, through either a traditional approach or a hand-assisted technique [9–12]. Cuneiform resections of the transverse colon or segmentary resections of the splenic flexure have also been proposed.

These controversial approaches are based on some studies that have underlined the constant poor prognosis of SFC [9–12] and on some theories about differences in lymphatic drainage [9–13] and differences in the embryological origin of splenic flexure cancers [15, 16]. These hypotheses lacked confirmation, and the poor prognosis of SFC could be more simply related to a late diagnosis, the advanced stage, and its being frequently accompanied by intestinal obstruction [4, 10, 12], which has a negative impact on survival [5, 17, 18]. Moreover, no significant survival differences were observed between patients with SFC and those with other colorectal cancers undergoing curative surgery [4, 12, 17]. The clinical presentation characterized by occlusion may also be due to the splenic flexure anatomy with is peculiar acute angle [7, 19].

The oncological debate regarding SFC lymphatic drainage arises from the inconstant triple lymphatic drainage route: (1) proximally to the splenic hilum along the pancreatic tail and the retropancreatic space; (2) distally to the lymphatic pedicles of the superior mesenteric vessels through the left branch of the middle colic vessels, inferiorly through the inferior mesenteric vessels through the axilla abdominis of Bacon along the inferior mesenteric artery, and towards the iuxtameseraicus lymphatic pedicle along the inferior mesenteric vein [5, 6, 12, 13, 20–23]; and (3) to the left accessory aberrant colic artery area (LAACA), when present [23].

The vascularization of SF is also variable, representing a surgical problem; in 89% of cases, vascularization is provided from the inferior mesenteric artery (IMA) by the left colonic artery (LCA), while in the remaining 11% of cases, it is provided from the superior mesenteric artery (SMA) by the middle colic artery (MCA) [14]. However, the middle colic artery is entirely absent in 5–22% of cases [14, 24], and in these cases, the splenic flexure is supplied by the ileo-colic or right colic artery, originating from the superior mesenteric artery, and by the left colic artery [14, 24, 25].

The choice of an appropriate resection is a great challenge. Almost a century has passed, since Jameson proposed the main principles of radical surgery for colon cancer: removal of the cancer and associated regional lymph nodes by harvesting them at their vascular roots. A sufficient bowel resection, complete resection of the mesocolon en-bloc, and central ligation of the vessels are required [13].

In 1980, Heald and colleagues [26] introduced the revolutionary concept of total excision of the mesorectum for rectal cancer, and after 11 years, Hohenberger proposed complete mesocolic excision (CME) as a surgical technique to achieve more favorable oncologic results from colon cancer surgery [27]. CME with central vascular ligation (CVL) is the latest trend in colorectal cancer treatment and has been theorized, standardized, and validated by several studies proving that better oncological specimens are achieved with this method than using the standard techniques [28, 29]. CME with CVL is the basis of extensive lymph node dissection along the feeding vessels and has a significant effect on regional recurrence and systemic dissemination, thereby improving survival in stage I–III colon cancers [30, 31].

In CME for splenic flexure colon cancer, dissection of both the transverse and descending mesocolon must be considered [22]. In addition, due to blood vessel variability and complex lymph flow, including aberrant lymph drainage in the splenic flexure sites, node dissection may be tailored to each case [5, 12, 13, 20, 22].

In this study, 73.5% of the procedures were splenic flexure resections, and only 31 were extended resections (23.1% extended left colectomy and 3.6% right colectomy).

The choice to perform a tailored resection is shared by several authors, considering the open debate regarding the best resection for SFC. In this series, despite the experience of different surgeons from different centers, the patients were treated with a similar laparoscopic technique for the same pathology and achieved comparable, satisfactory oncologic parameters (i.e., the number of lymph nodes and specimen length) [21, 32, 33]. All surgeons followed the same oncological principles of central vascular ligation with complete mesocolic excision to retrieve an adequate number of lymph nodes (18.3 ± 8.4). The lymph node numbers obtained were comparable to those found in the literature (mean LN number = 15) obtained for right and left colectomy [34]. In this experience, despite the number of segmental resections, the mean specimen length was adequate, having a mean value of 28.1 ± 16.6 cm.

Regarding multi-organ resections, Khafagy et al. reported that splenectomy and distal pancreatectomy for splenic flexure colon cancer did not improve long-term survival [6]. The surgeons involved in the present study agree with the mentioned authors that splenectomy should be performed only in very advanced cancers, tumors adherent to the spleen and accidental spleen lesions [4, 6, 7, 25].

Simultaneous resections of other organs were performed in 13 of the 102 complete laparoscopic procedures (10 peritoneal resections, 2 small-bowel resections and 1 stomach resection). In 11 cases, multi-organ resection was performed for T4 tumors, but in 2 patients, resection of the peritoneum was necessary for suspected (but not confirmed by definitive pathological examination) macroscopic infiltration.

In this study, all procedures began as laparoscopies. Immediate conversion to open surgery, with no part of the procedure performed laparoscopically, was considered an exclusion criterion. In the literature, few studies have described the feasibility and oncological efficacy of laparoscopic surgery for SFC, and this limits any attempt at standardization [21, 32, 33, 36–39]. In this experience, the short- and long-term outcomes were evaluated based on complete laparoscopic procedures to measure the feasibility and efficacy of the procedure.

Laparoscopic surgery for SFC is considered technically demanding. One of the reasons for the complexity of this surgery is the colonic splenic flexure anatomy and the necessity for the oncologically correct detachment of the neoplastic colonic segment from the spleen, pancreas, and stomach, avoiding intra-operative lesions of these organs [35]. These laparoscopic maneuvers are considered among the most challenging in minimally invasive colorectal surgery.

A novel approach was recently proposed by Matsumura et al. with a lateral-to-medial access to the left transverse mesocolon, a medial-to-lateral approach to the left mesocolon, and take-down of the remnant SF. This technique has been described by the authors as a new safe and effective surgical strategy to treat SFC [40].

In the present study, the conversion rate was 12,5%, higher than the overall conversion rates found in the literature, which range from 0% to 7,5%. The conversion rate ranges from zero in the recent experiences of Carlini [33] and Pisani-Ceretti [21] to 6–7.5% in other studies. [36, 39]. A recent review conducted by Martinez-Perez recorded a mean conversion rate of 2.5% [34], while Kim et al. reported two laparoscopic conversions (6.1%) due to anatomical abnormalities and anastomotic site twisting [40].

In this series, the reasons for conversion were technical difficulties in nine cases, extended tumors in five cases, and major bleeding not manageable in laparoscopy in one case. The difficulties were related to transverse dilatation in subocclusive tumors (two cases), bulky tumors (four cases), and BMI > 30 (three cases). As shown in Fig. 2, the number of converted procedures over the observed period was distributed randomly with no relation to the surgical skills and experience implemented.

The authors believe that the finding of the highest rate of conversion to open surgery in this series is related to the great experience with laparoscopic surgery of the surgeons involved in this study, which indicated laparoscopic resection even in borderline cases (subocclusion, obese, T4). These patients, in other centers with less laparoscopic surgery experience, would directly be assigned to open resection.

In summary, complete laparoscopic resection of SFC appears to be a safe and feasible technique [32]. Meticulous pre-operative assessment, correct surgical indication, and the surgeon's experience enable oncological resection to be performed.

Concerning short-term outcomes, Beisani et al. conducted a multi-center study and compared subtotal colectomy (STC) with left colectomy (LC) in 144 patients. The authors found a higher surgical morbidity in the STC group, mainly due to mild postoperative ileus, but no significant differences in hospital stay [39]. In a recent meta-analysis, Martinez-Perez reported a significantly minor blood loss, a shorter time to return to an oral diet and a shorter hospital stay after using a laparoscopic approach [34]. However, the authors did not find any significant differences in favor of laparoscopic LC in terms of length

of hospital stay or postoperative complications. Kim and his group compared the short- and long-term outcomes of laparoscopic surgery with those of conventional surgery in 51 consecutive patients. Laparoscopy showed better short-term outcomes than open surgery with longer operative times (p 0.001), as well as acceptable long-term outcomes [40]. Carlini et al. compared extracorporeal and intracorporeal anastomoses and did not find any significant difference in length of stay (mean days 8.0 ± 1.1 vs 8.9 ± 1.3) or morbidity rate. Only two minor complications were reported (one each of grades I and II of the Clavien–Dindo classification) [33]. Similarly, Swaid and his group, comparing different anastomoses, did not find significant differences in postoperative complications such as ileus, anastomotic bleeding, need for transfusion, pneumonia, myocardial infarction, readmission rate, or 30-day mortality. Length of stay was statistically longer in their extracorporeal group ($p = 0.001$) [41]. In this study, the short-term outcomes, in terms of time to first flatus, time to first stool and complete oralization, morbidity, and mortality, were comparable to those obtained with other laparoscopic colonic resections. These outcomes were better than those obtained in the majority of studies reporting open splenic flexure resections [42, 43]. This result can be explained by the well-known advantages of laparoscopy in terms of postoperative morbidity and mortality [44, 45].

The incidence of mucinous tumors was consistent with the literature; in a large study on 167 patients, the incidence of mucinous adenocarcinoma in SFC was similar to that observed in right colon cancer (11% vs 7.5%, respectively), but was higher in left (6.5%) and sigmoid (2.5%) cancers [4].

In terms of long-term oncological outcomes, the results of this study are consistent with other authors' findings [40]. The cumulative 5-year overall survival (OS) rate found in this study was 84.3%, and the cumulative 5-year disease-free survival (DSF) rate was 87.8%. Carlini et al., with a mean follow-up period of 58 months, did not find local recurrence; 2 patients (10%) developed liver metastases and died 14 and 19 months after surgery [33]. These findings confirm that laparoscopic resection limited to the splenic flexure is a safe and efficient technique in terms of the oncological results obtained.

This study is limited by the retrospective analysis of the database, which was obtained from three high-volume institutions, resulting in a possible bias in terms of prospective data collection.

Nevertheless, the study reports a large and homogeneous population who were submitted to a full laparoscopic resection for SFC; there were no emergency cases, and all procedures were performed by a small number of skilled surgeons. Finally, criteria were accurately selected to decrease the risk of bias.

Conclusions

The laparoscopic resection of colonic splenic flexure cancers is a feasible, safe, and effective procedure in high-volume centers. Compared to the results obtained in other laparoscopic colonic resections, the short- and long-term outcomes are similar, but the conversion rate for this procedure is higher. In this study, the conversion rate was even higher due to the inclusion of borderline laparoscopic patients (subocclusion, obese, T4), which was in turn due to the experience of the surgeon involved.

Compliance with ethical standards

Conflict of interest The authors have no conflicts of interest or financial ties that are relevant to this article to disclose.

Research involving human participants and/or animals This research involves only human participants, no animals and it is in accordance with the 1964 Helsinki declaration. This study was first approved by the institutional Ethics Committee of *Sant'Eugenio Hospital—Rome* and then approved by the Institutional Ethics Committee of every participating center.

Informed consent Informed consent was obtained from all patients.

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